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Further Comments on Stability of Interface between Solar Wind and Geomagnetic Field

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It has been pointed out [Dessler, 1961] that surface magnetometer data suggest that the interface between the solar wind and the magnetosphere is stable rather than turbulent as commonly assumed. It is my purpose in this letter to show how the introduction of the concept of a standing shock wave [Axford, 1962; Kellogg, 1962] maintained by the solar wind impinging on the magnetosphere makes satellite and space-probe data consistent with the conclusion that the interface between the solar wind and the magnetosphere is stable.

Figure 1 illustrates the standing shock wave

around the front of the magnetosphere as described by Axford [1962] and Kellogg [1962]. There are two distinct boundaries: (1) the surface between the magnetosphere and the solar wind, which normally appears at about $10R_E$ geocentric distance near the subsolar point, and (2) the shock transition between the supersonic solar wind and the compressed, slower solar wind region; the shock transition is located at about $14R_E$ near the subsolar point. Inside the magnetosphere, the magnetic field is relatively steady in time and decreases in strength monotonically with increasing radial distance. Be-

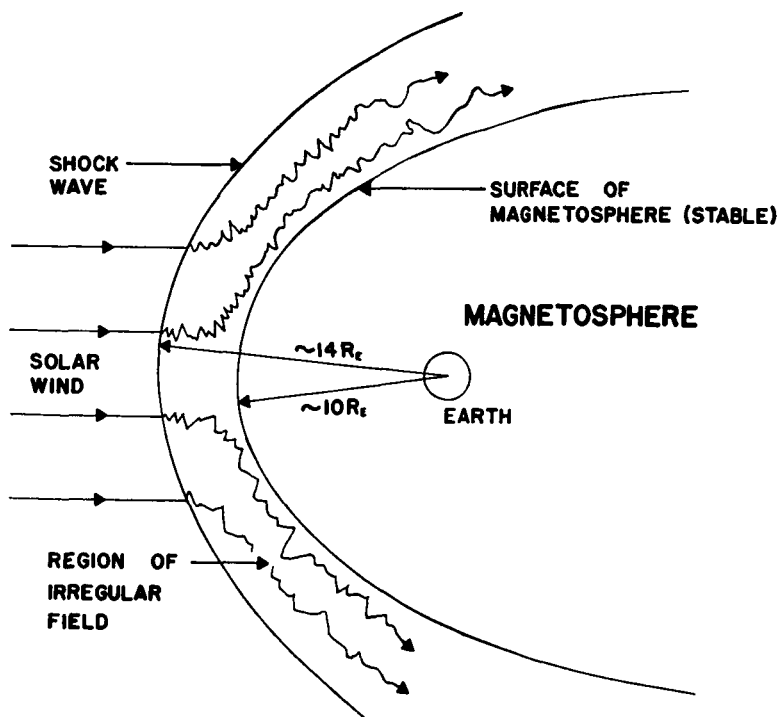


Fig. 1. A sketch (after Axford [1962] and Kellogg [1962]) illustrating the interaction between the solar wind and the magnetosphere. It is the magnetospheric boundary (at about $10R_E$ geocentric distance on the sunward side) that appears to be stable in the solar wind flow.

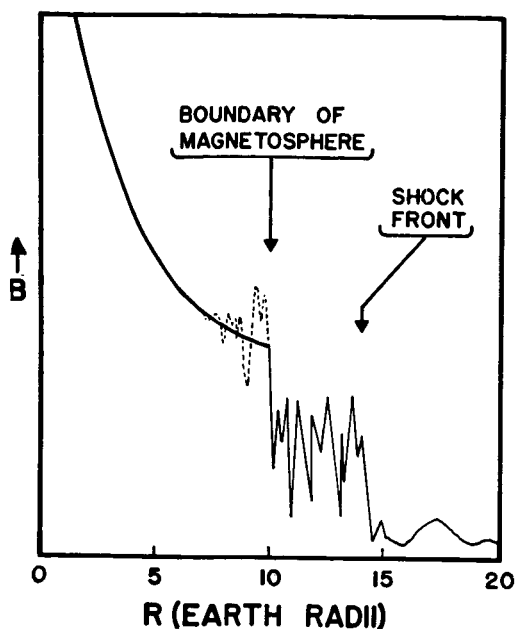


Fig. 2. Sketch of magnetic field versus radial distance, in the sunward direction (after satellite and space probe measurements, *Sonett et al.* [1960]; *Ness et al.* [1961]; *Cahill and Amazeen* [1962]). The solid line shows the very sudden transition from smooth to irregular field. The dashed line indicates what one might expect either if the magnetospheric boundary were turbulent or if the magnetic irregularities measured between the boundary of the magnetosphere and the shock front were hydromagnetic waves that propagated into the magnetosphere.

tween the magnetosphere and the shock front, the magnetic field is irregular. Beyond the shock front, the field is less irregular.

A sketch of magnetic field strength as a function of radial distance is shown in Figure 2. The feature that is, at least qualitatively, in common with all the satellite and space-probe experiments [*Sonnett et al.*, 1960; *Ness et al.*, 1961; *Cahill and Amazeen*, 1962] is that just inside the boundary of the magnetosphere the field is steady, whereas it becomes quite irregular just outside the boundary. This phenomenon is shown by the solid line in Figure 2. The dotted curve shows what we might expect if the irregular fluctuations observed between the magnetosphere and the shock front were hydromagnetic waves that propagated inward, or if these waves were generated by turbulence at the boundary of the magnetosphere. (Turbulence, in its commonly

understood form, i.e., irregular motion of geomagnetic field lines, must generate hydromagnetic radiation; true turbulence would put a significant fraction of the radiated energy into the isotropic mode, fast mode, that would propagate across field lines.) The only explanation that has thus far been put forth that can account for both the rocket observations sketched in Figure 2 and the previously discussed surface observations is that the flow of solar plasma past the magnetosphere is grossly stable.

Cahill and Amazeen [1962], from examination of Explorer 12 penetrations of the boundary, have independently concluded that the magnetospheric boundary is stable. They find that the boundary thickness is of the order of 100 km, and that, 'The boundary is stable in that, during the penetration period of 100 sec, the boundary has not moved back and forth past the satellite.'

It cannot be unambiguously determined from a single magnetometer in space whether the fluctuations seen between the shock front and the magnetosphere are propagating hydromagnetic waves or quasi-stationary structures that are being swept past the detector by the flow of solar wind behind the shock (as shown in Figure 1). However, if these fluctuations are hydromagnetic waves, as suggested by *Sonett et al.* [1960], then the impedance mismatch across the interface into the magnetosphere from one medium to the other must be very great.

The hypothesis of a stable magnetospheric boundary, if correct, has implications of fundamental importance to geomagnetism. One example is the meaning of the K_p index. It has been traditionally assumed that a low K_p index indicates little or no solar plasma flowing past the magnetosphere, whereas a high K_p index indicates an enhancement of the flow of solar plasma. However, if the flow of solar plasma past the magnetosphere is always stable, large magnetic disturbances, which define a high K_p , must be generated by a varying combined pressure of solar wind and solar magnetic field on the magnetosphere. That is, the K_p index is a measure of the time rate of change of plasma plus magnetic pressure on the magnetosphere.

REFERENCES

- Axford, W. I., The interaction between the solar wind and the earth's magnetosphere, *J. Geophys. Research*, 67, September 1962.

Cahill, L. J., and P. G. Amazeen. The boundary of the geomagnetic field, manuscript in preparation, 1962.

Dessler, A. J., The stability of the interface between the solar wind and the geomagnetic field, *J. Geophys. Research*, 66, 3587-3590, 1961.

Kellogg, P. J., Flow of plasma around the earth, *J. Geophys. Research*, 67, September 1962.

Ness, N. F., T. L. Skillman, C. S. Scarce, and J. P. Heppner, Magnetic field fluctuations on the earth and in space, *Proceedings Kyoto Con-*

ference on Cosmic Rays and the Earth Storm, vol. 2, 27-33, Physical Society of Japan, Tokyo, 1962.

Sonett, C. P., E. J. Smith, and A. R. Sims, Survey of the distant geomagnetic field: Pioneer 1 and Explorer 6, in *Space Research*, edited by H. Kallman-Bijl, pp. 921-937, North-Holland Publishing Company, Amsterdam, 1960.

(Received August 15, 1962.)

Code - none

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